ICC2019 congress, Delft, August 29 and 30

A psycho-physiological approach to Environmental comfort

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Comfort and the physical environment

What are we trying to achieve ?

From fundamental understanding to practical application!

How have we gone about it ?

Vast numbers of studies

How do we move forward in the future ?

Static to dynamic – how do people achieve comfort?

Environmental comfort

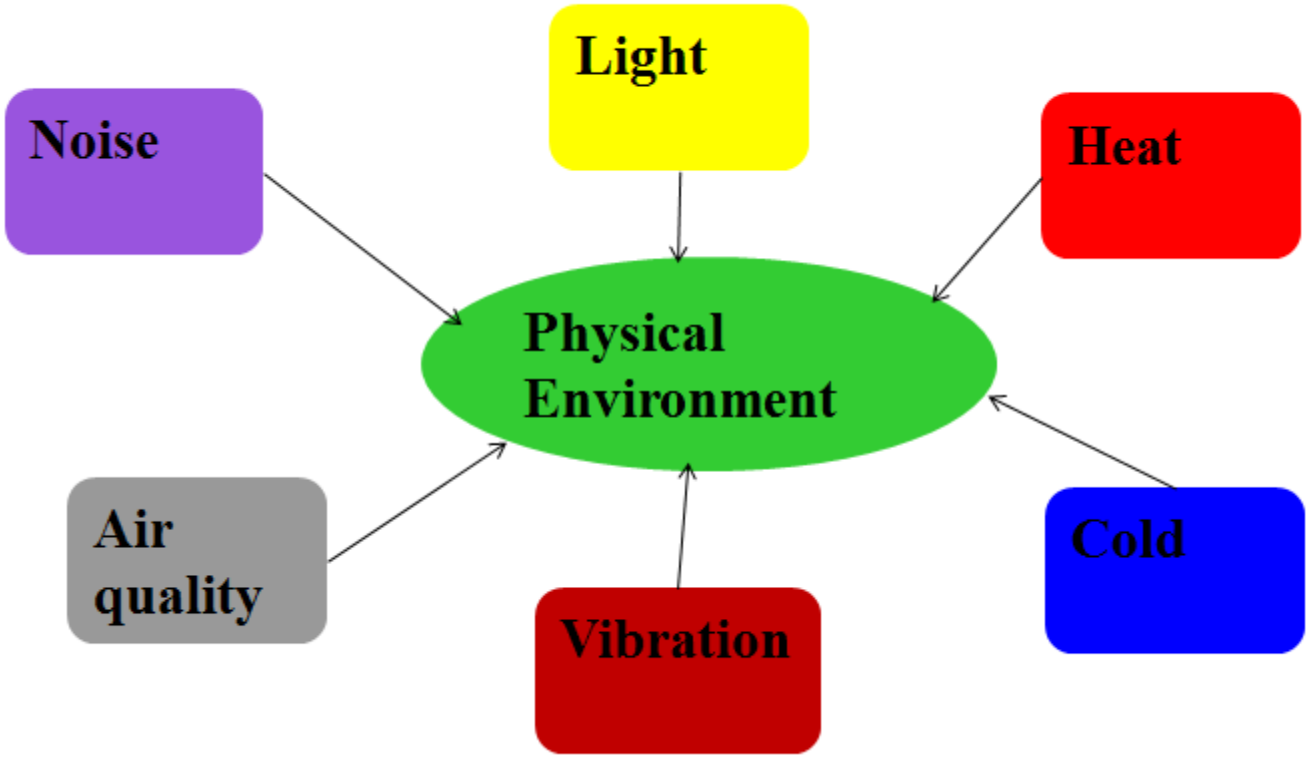
That condition of mind which expresses satisfaction- with the physical environment

Psychological - subjective, behavioural

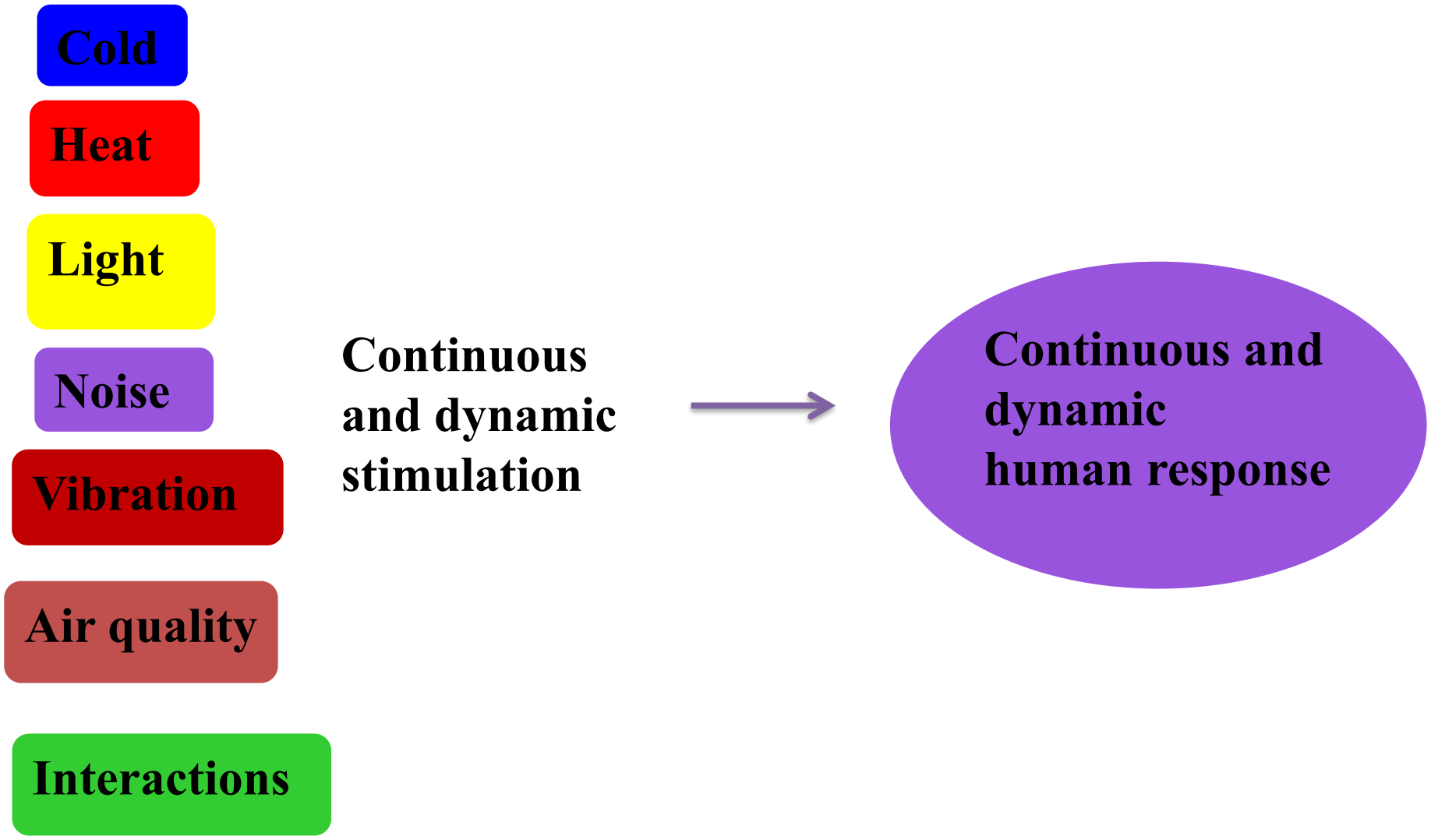
No change!

But what happens when uncomfortable?
Is striving for comfort a part of the human condition?
Is discomfort always bad?

How do we consider the physical environment ?



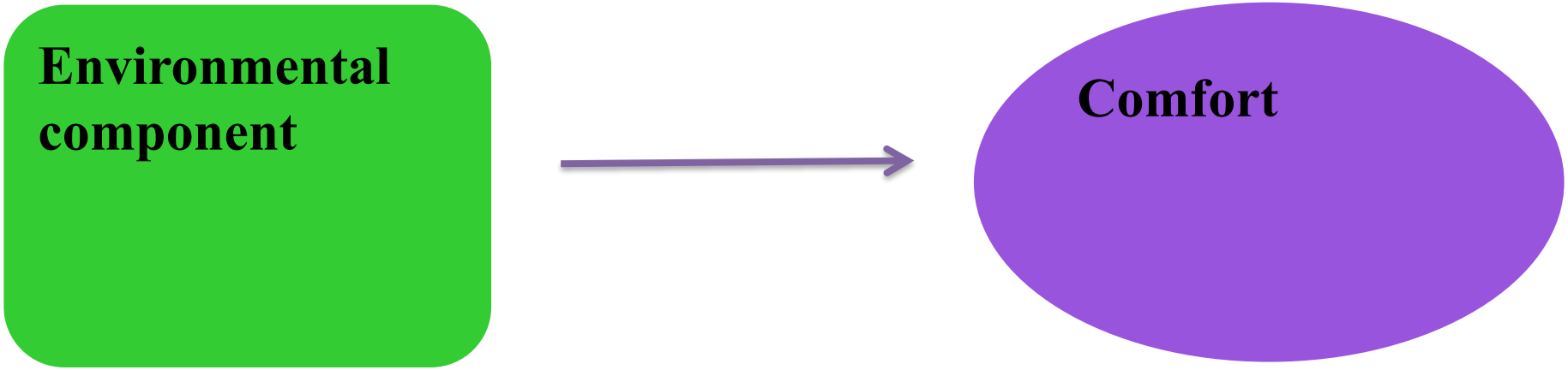
Response to the 'total' integrated environment

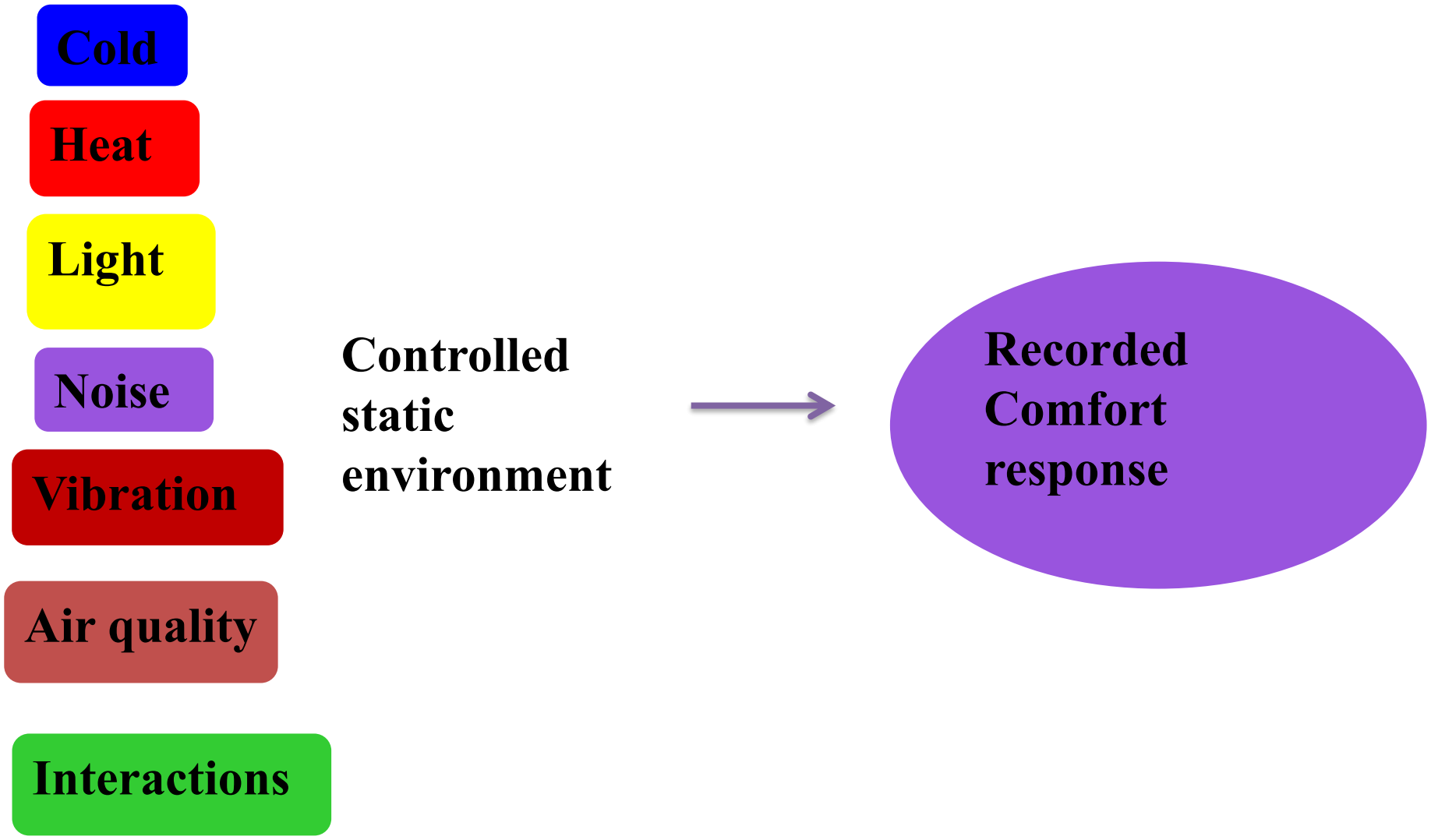


So how do we study human environmental comfort?

- Identify environmental components
- Identify relevant environmental variables for human response
- Study the effects of variables in isolation, individually and in combinations
- Build a picture of how humans will respond to complex environments
- Generate rational models from engineering, the laws of physics etc
- Investigate physical models
- Generate practical models from actual environments
- Evaluate knowledge in field experiments
- Develop environmental indices

Environmental components usually studied individually




Cold
Heat
Light
Noise
Vibration
Air quality
Interactions
Controlled static environment
Recorded Comfort response

Empirical studies - Laboratory and field

Subjective Measures

Sensation, comfort, Preference, acceptability, satisfaction

Objective measures

Skin temperature, heart rate, sweat loss, acceleration of body…

Behavioural measures

Move and move away

Change posture or position;

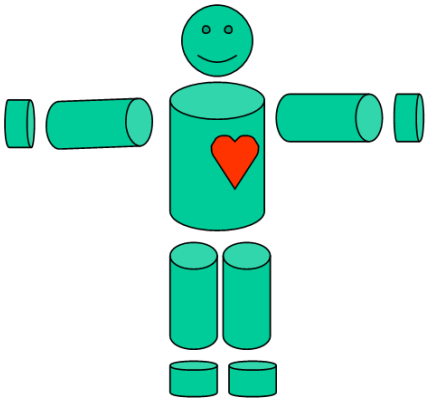
Adjust input to body

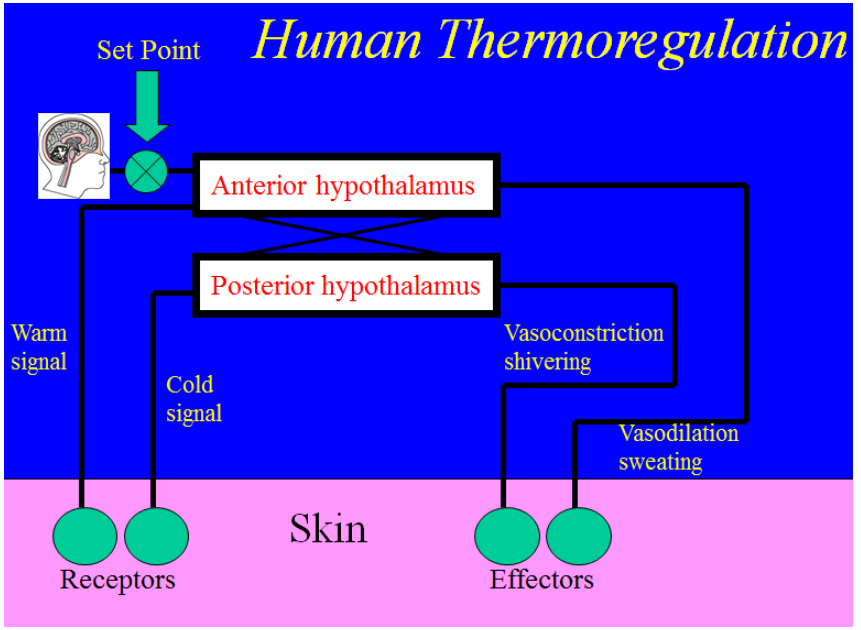
Adjust clothing, slow down, sun glasses, ear defenders;

Adjust at source (incl technology)

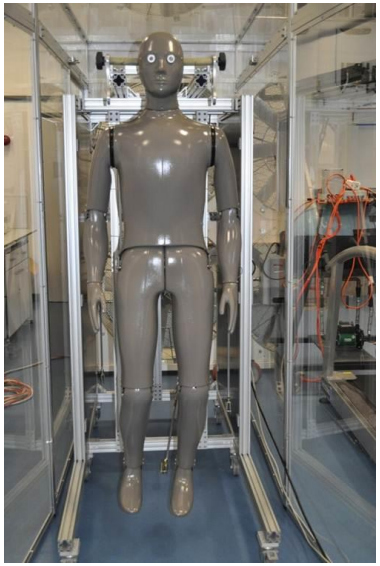
Operate fans, use screens, thermostat, open windows, vibration isolation, noise reduction etc.

Rational computer models





Physical models (thermal manikins)



Examples of outcomes

Sound/Noise

Variables

Level

Frequency

Outcomes

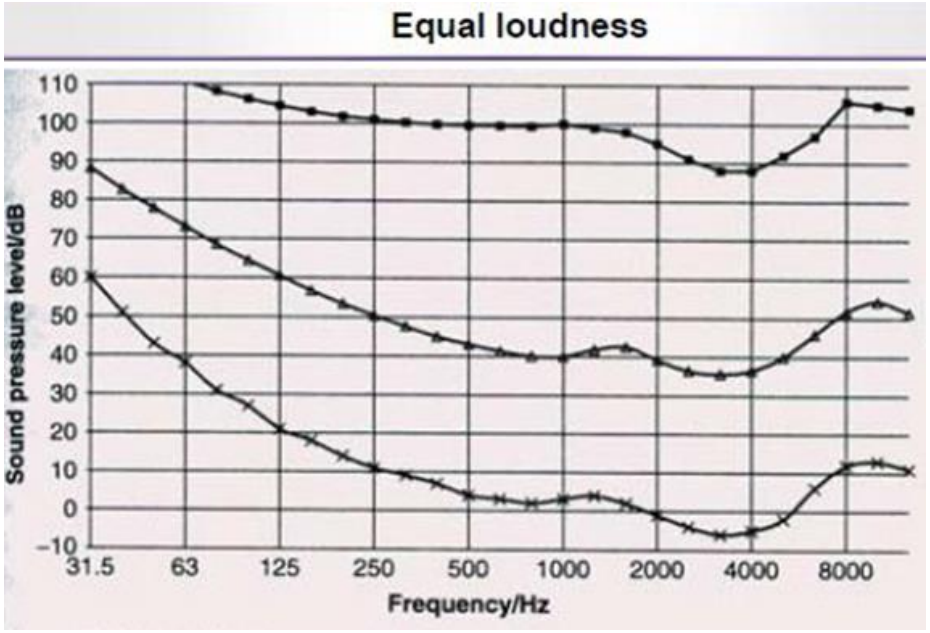
Discomfort

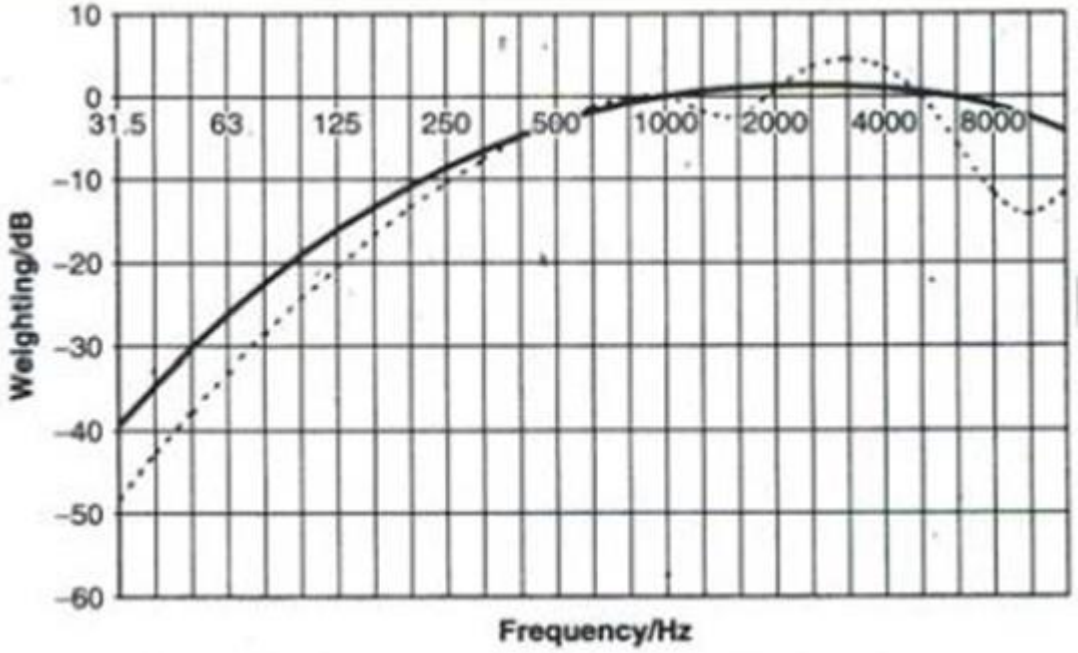
Annoyance

Indices

dB(A)

L_{eq}

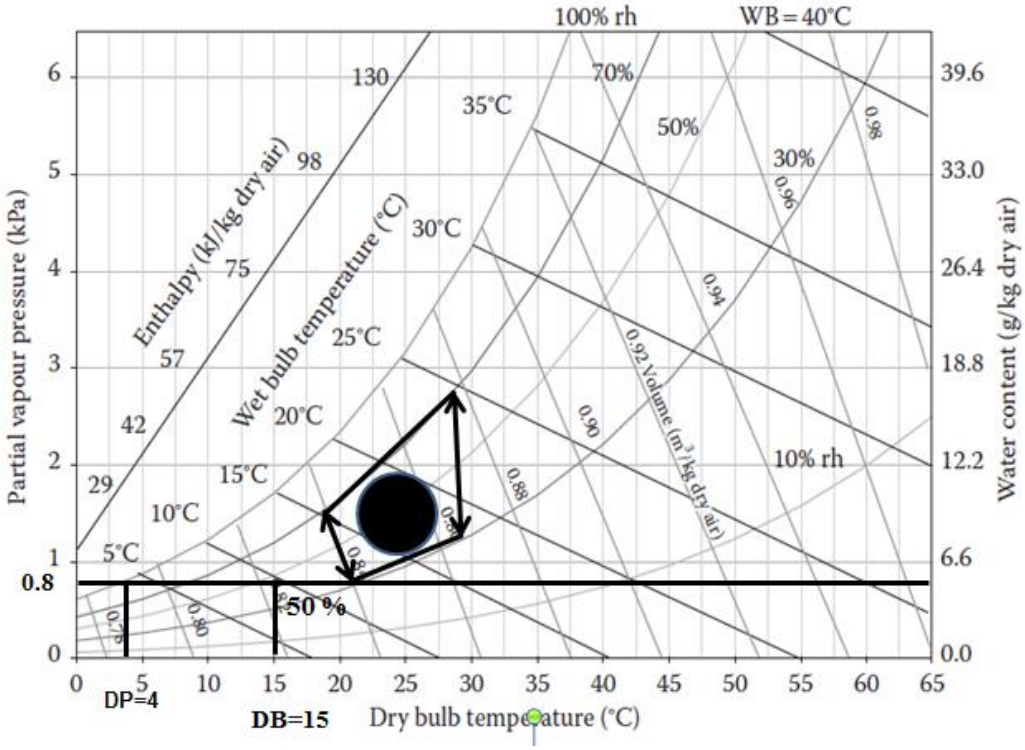




Thermal

Variables

Air temperature
Radiant temperature
Humidity
Air velocity
Clothing
Activity

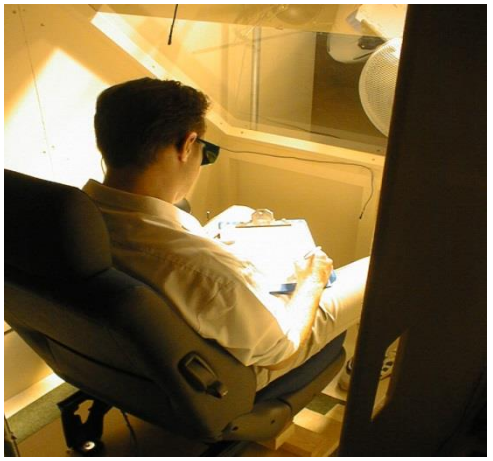


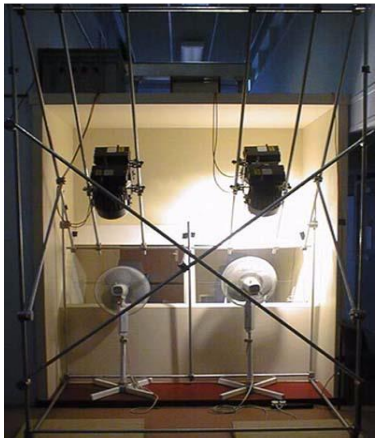
Outcomes

Sensation, comfort, preference, pleasure, discomfort, Dissatisfaction, stickiness

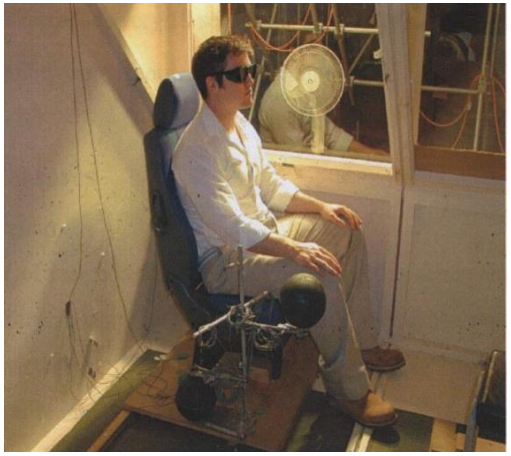
Indices

PMV/PPD Thermal comfort indices






LAND ROVER
R952 BDU



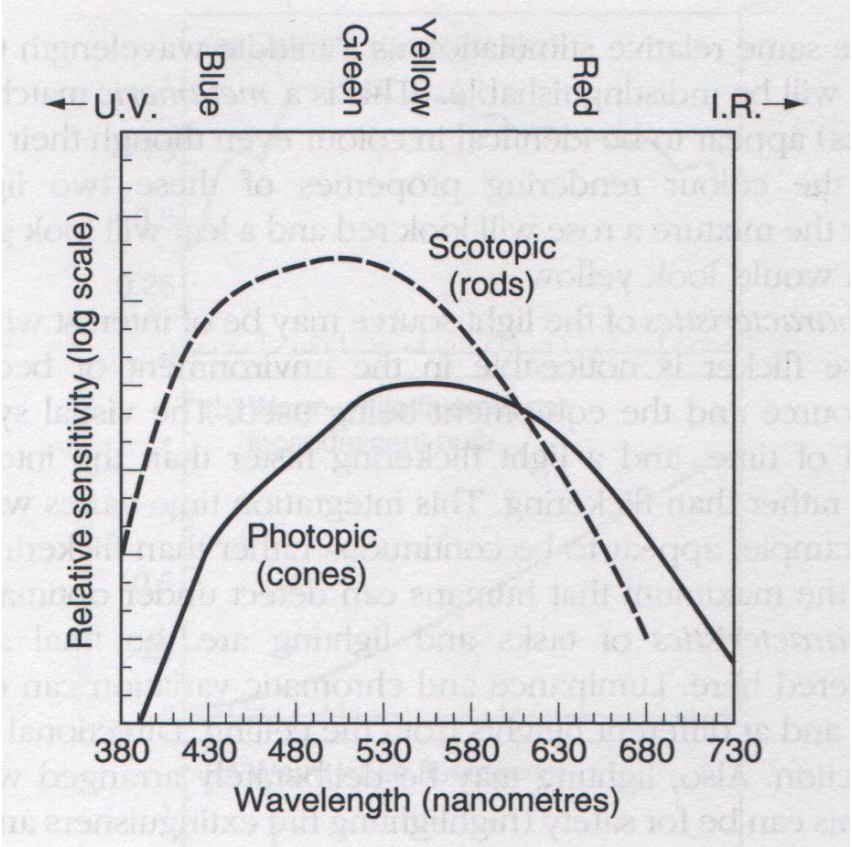
Vision and lighting

Variables

Light level
Wavelength
Eye condition

Outcomes

brightness
Glare
Pleasant



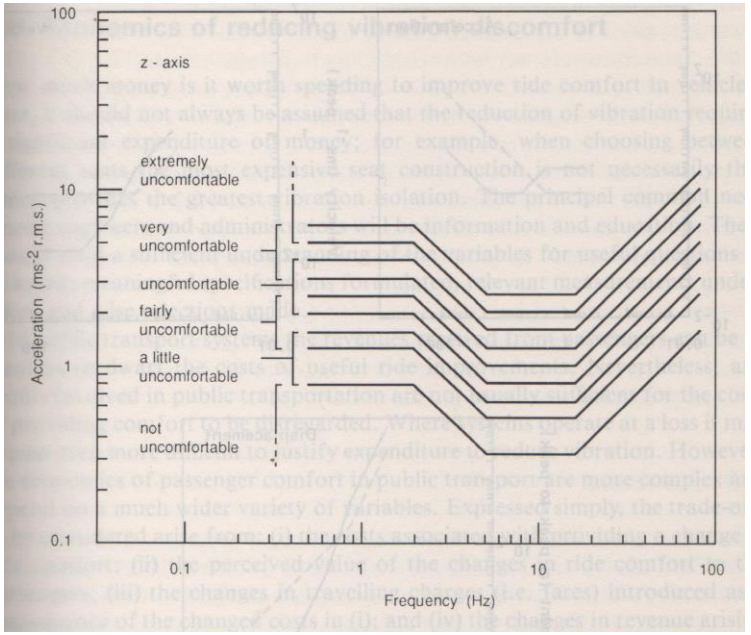
Indices

Lux – colour corrected illuminance

Vibration

Variables

Level
Frequency
Axis
Input point
Whole body
Hand-arm

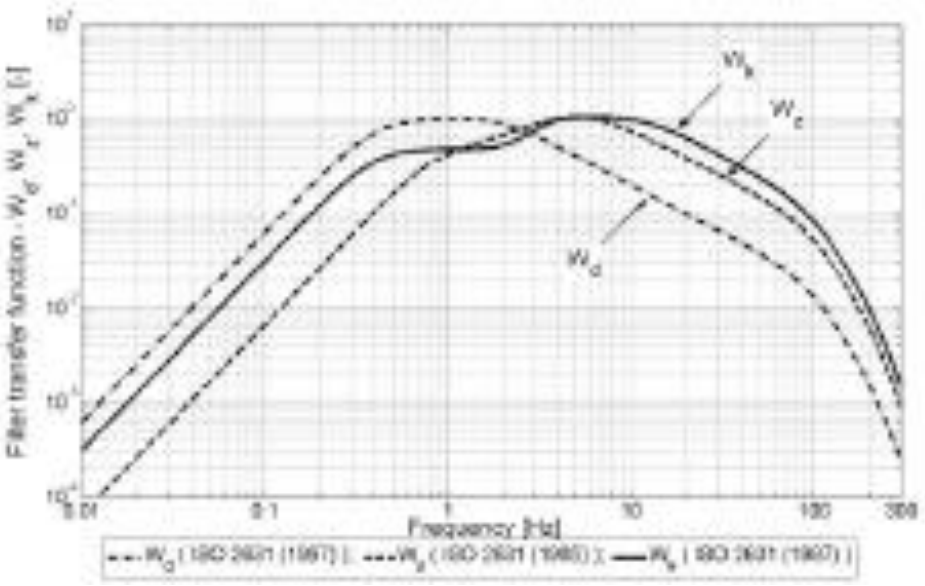


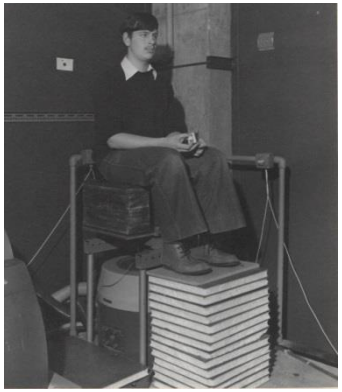
Outcomes

Discomfort
Annoyance

Indices

Weighted acceleration
Vibration Dose Value





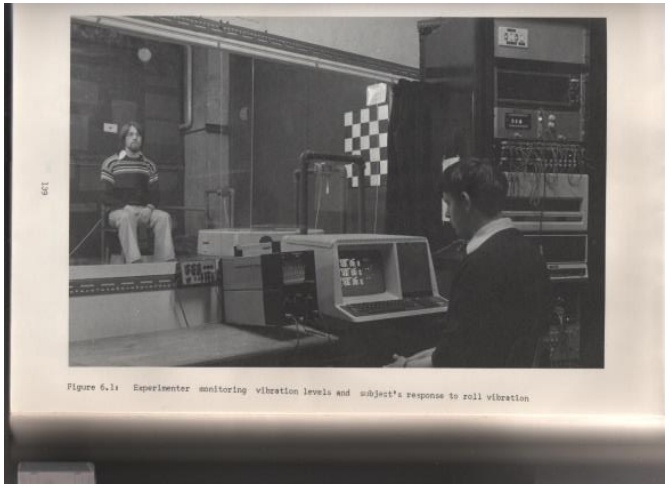
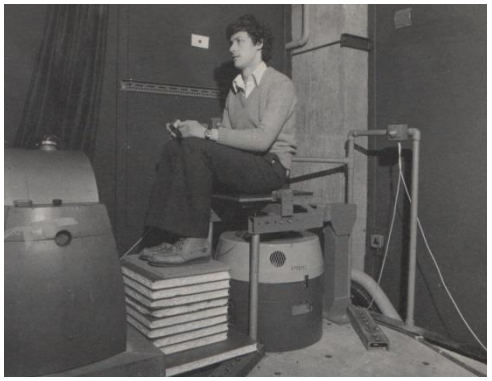


Figure 6.1: Experimenter monitoring vibration levels and subject's response to roll vibration



INTERNATIONAL STANDARD

ISO 28802

First edition
2012-03-01

Ergonomics of the physical environment — Assessment of environments by means of an environmental survey involving physical measurements of the environment and subjective responses of people

Ergonomie de l'environnement physique — Évaluation au moyen d'une enquête environnementale comprenant des mesurages physiques et des réponses humaines subjectives

INTERNATIONAL STANDARD

ISO 10551

Second edition
2019-06

ISO 10551:2019

ERGONOMICS OF THE PHYSICAL ENVIRONMENT -- SUBJECTIVE JUDGEMENT SCALES FOR ASSESSING PHYSICAL ENVIRONMENTS

Reference number
ISO 10551:2019(E)

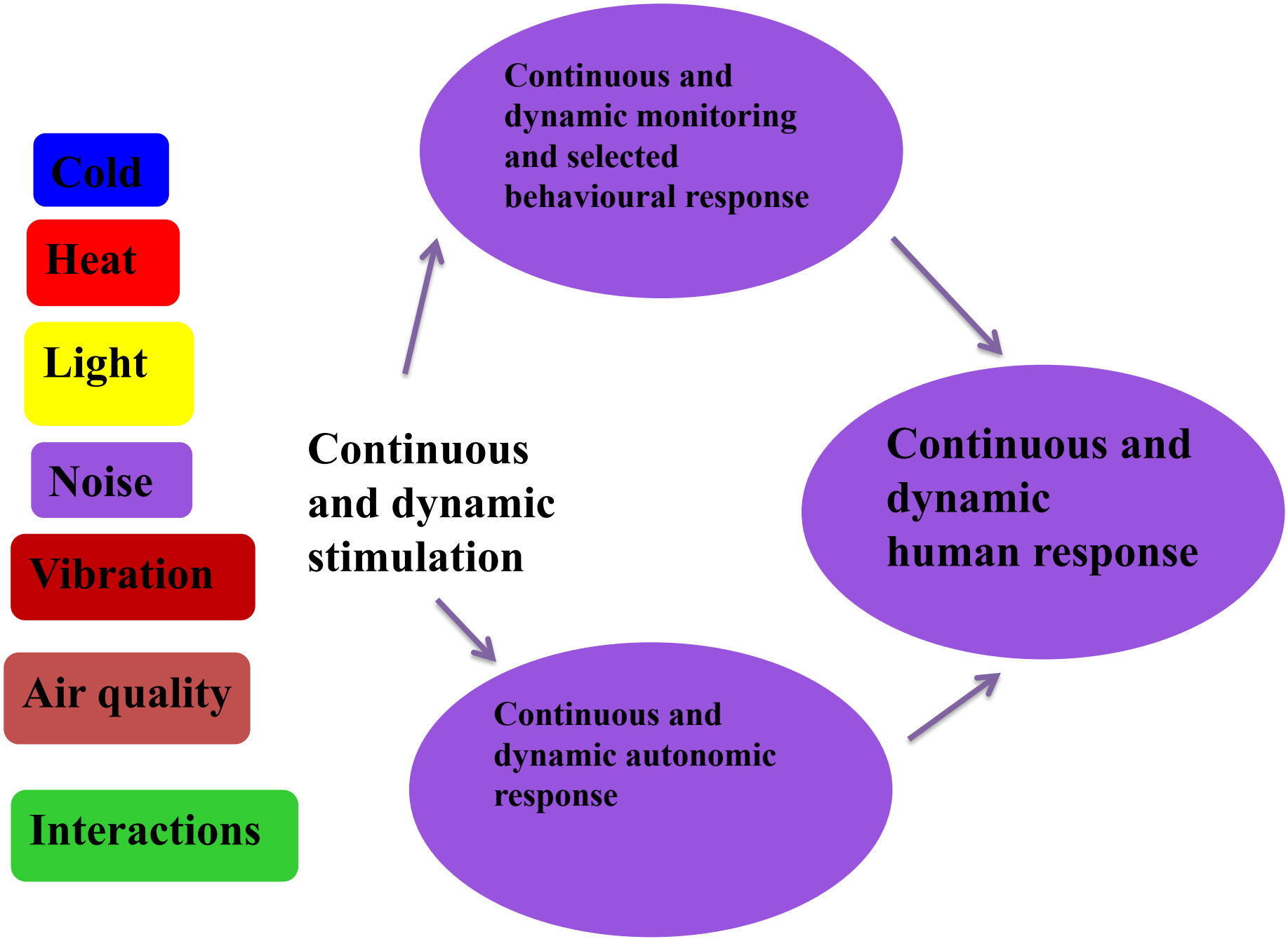
Environment	Parameters	Instrument specification	Subjective terms	Suggested subjective scales (sl. = slightly)
Thermal	Air temperature	ISO 7726	ISO 10551	
	Radiant temperature	ISO 7726	Sensation 3 to -3	Hot, warm, sl warm, neutral, sl cool, cool, cold
	Humidity	ISO 7726	Uncomfortable 1-4	Not uncomfortable, sl uncomfortable, uncomfortable, very uncomfortable
	Air velocity	ISO 7726	Stickiness 1-4	Not sticky, sl sticky, sticky, very sticky
	Metabolic rate	ISO 8996	Preference 1-7	Much warmer, warmer, sl warmer, no change, sl cooler, cooler, much cooler
	Clothing insulation	ISO 9920		
		ISO 7730	Draughtiness 1-4	Not draughty, sl draughty, draughty, very draughty
			Dryness 1-4	Not dry, sl dry, dry, very dry
			Satisfaction 1-2	Satisfied, not satisfied
			Acceptability 1-2	Acceptable, not acceptable
Acoustical	DB(A)	IEC 61672-1	Annoyance 1-4	Not annoying, sl. annoying, annoying, very annoying
	DB(A) Leq.	IEC 61672-1	Preference 1-4	No change, sl. Quieter, Quieter, Much Quieter
		ISO 9612	Acceptability 1-2	Acceptable, not acceptable
			Satisfaction 1-2	Satisfied, not satisfied

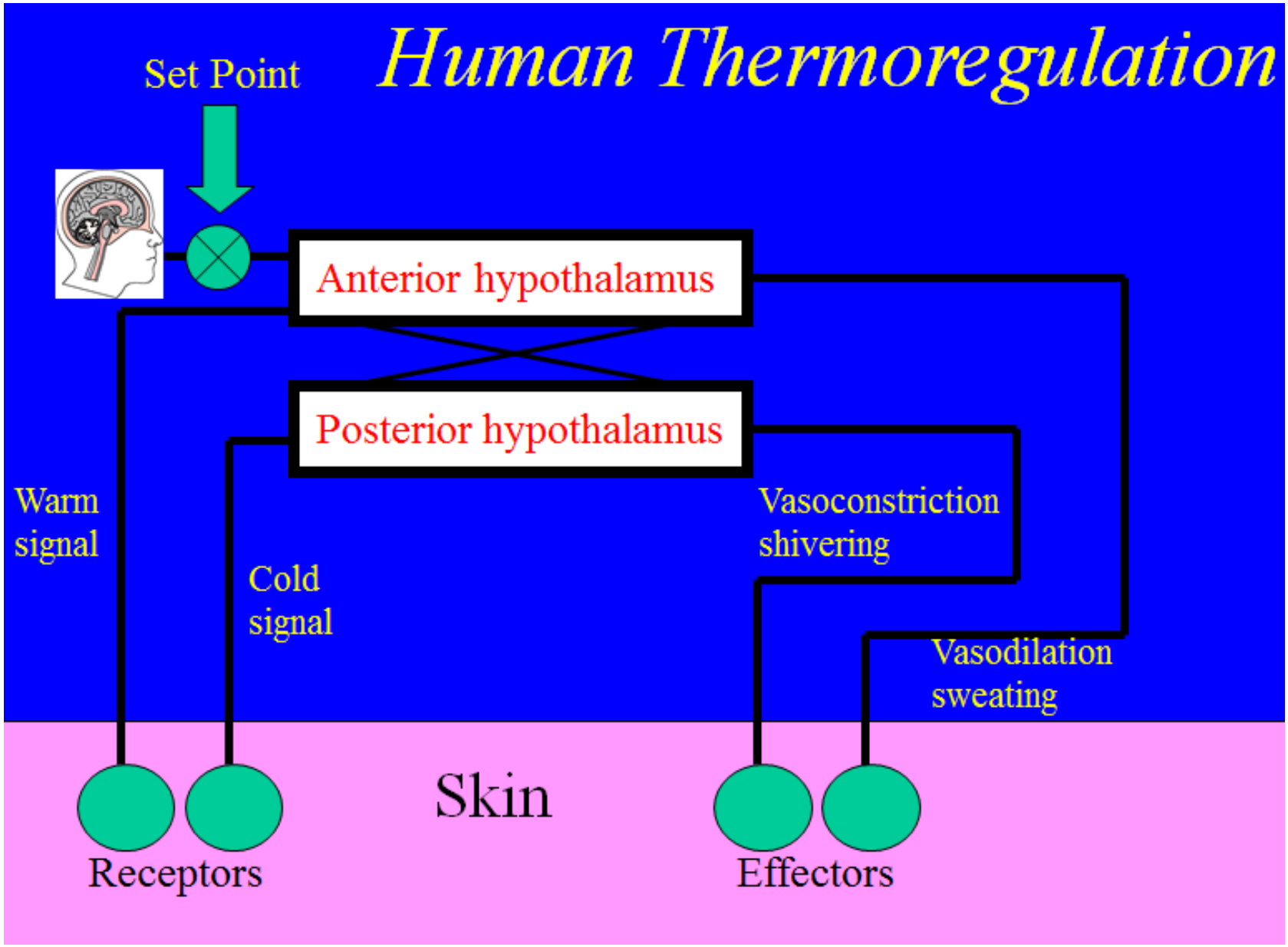
Acoustical	DB(A) DB(A) Leq.	IEC 61672-1 IEC 61672-1 ISO 9612	Annoyance 1-4 Preference 1-4 Acceptability 1-2 Satisfaction 1-2	Not annoying, sl. annoying, annoying, very annoying No change, sl. Quieter, Quieter, Much Quieter Acceptable, not acceptable Satisfied, not satisfied
Visual and lighting	Horizontal illuminance	CIE 69 standard Illuminance meter	Visual discomfort 1-4 Preference 1-7 Acceptability 1-2 Satisfaction 1-2	No discomfort, sl. discomfort, Discomfort, Much discomfort. Much darker, Darker, sl. Darker, No change, sl. lighter, lighter, much lighter. Acceptable, not acceptable Satisfied, not satisfied
Air Quality	CO_2 levels	Specified by manufacturers	Smelliness Acceptability 1-2 Satisfaction 1-2	Very smelly, Smelly, sl Smelly, Not smelly Acceptable, not acceptable Satisfied, not satisfied
Vibration	Acceleration in vertical, horizontal and fore-and aft directions with respect to a person. Sometimes also roll, pitch and yaw.	ISO 8041 ISO 2631-1	Uncomfortable 1-6 Annoying 1-4	Not uncomfortable, A little uncomfortable, Fairly uncomfortable, Uncomfortable, Very uncomfortable, Extremely uncomfortable. Not annoying, sl. Annoying, Annoying, Very annoying.
	Frequency weighted rms or vibration dose value.		Acceptability Satisfaction	Acceptable, not acceptable Satisfied, not satisfied

But people are not passive!

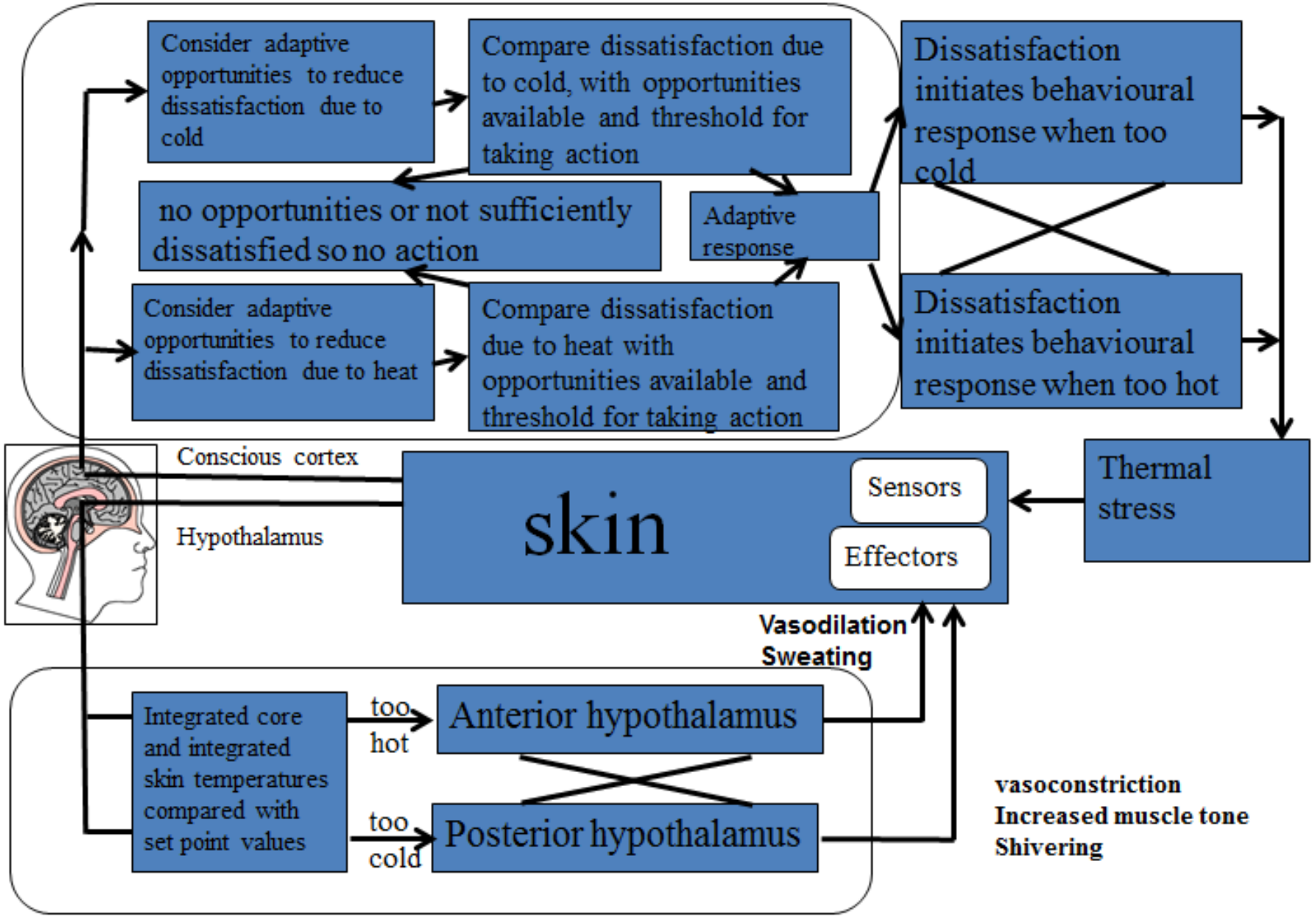
We can predict comfort conditions and when they are uncomfortable

‘but what happens then’?


Cold
Heat
Light
Noise
Vibration
Air quality
Interactions
Continuous and dynamic monitoring and selected behavioural response
Continuous and dynamic stimulation
Continuous and dynamic human response
Continuous and dynamic autonomic response


Human Thermoregulation
Set Point
Anterior hypothalamus
Posterior hypothalamus
Warm signal
Cold signal
Vasoconstriction shivering
Vasodilation sweating
Skin
Receptors
Effectors

Psycho-physiological system of thermoregulation



Adaptive opportunities - Vibration

Move and move away

Change rooms or workplaces or seats on a train. Often restricted by vehicle ‘workplace’.

Alter environmental component arriving on the body

Change posture but unpredictable effect, vibration isolation of seats for example.

Alter the environmental component at source

Technological adjustment - limited opportunity.

Adaptive opportunities for Heat

Move or move away

To a cooler position or environment. Change posture to increase surface area for heat exchange or to avoid or reduce solar or directional radiation.

Alter environmental component arriving on the body

Reduce clothing insulation – remove or adjust clothing, reduce activity level by slowing down or resting…

Alter the environmental component at source (Technological adjustment)

Turn heating down, use air conditioning, use fans, open windows..

Adaptive opportunities for cold

Move or move away

To a warmer position or environment. Change posture to decrease surface area for heat exchange or to capture or increase solar or directional radiation.

Alter environmental component arriving on the body

Increase clothing insulation – Add or adjust clothing, increase activity, use windbreak..

Alter the environmental component at source (Technological adjustment)

Turn heating up, avoid draughts, shield cold surfaces..

Adaptive opportunities - light

Move and move away

Change rooms or workplaces or orientation towards a light source.

Alter environmental component arriving on the body

Use screens…

Alter the environmental component at source

Technological adjustment – adjust lighting levels and distribution..

To understand how environmental comfort is achieved we need to use new methods

Focus groups

Discourse analysis

Qualitative methods

Individual differences in comfort responses between people are sometimes more to do with adaptive behaviour than actual physical conditions ?

People with disabilities have different adaptive opportunities than people without disabilities (e.g. to move around)

People of different cultures adapt to their environments in different ways but still require the same physical environments for comfort.

Conclusions

- **Indices, methods and standards, have been established to predict comfort conditions and the degree of discomfort for a wide range of conditions and environmental components.**

- **Considerations of comfort, across the range of environmental components (heat, light, noise etc), have not included the behavioural response of people.**

- **A challenge for the future is to determine adaptive opportunities, behavioural responses and the achievement of environmental comfort for all environmental components across populations.**